COLUMNAR SECTION

COLUMNAR SECTION OF THE SEDIMENTARY ROCKS OF THE SANTA CRUZ QUADRANGLE.

SCALE: 1 INCH = 2000 FEET.

System.	Series.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.
QUATERNARY		Alluvium, terrace deposits, and dune sand.	Qal Qt		0–50+	Sand, gravel, and clay.
TERTIARY	PLIOCENE	Santa Clara formation. (Merced formation along the coast.)	Tsc (Tmc)		500± (300±)	Coarse gravel, sand, and sandy clay, locally lignitic, of fresh-water origin. Represented along the coast by marine sandstone and sandy shale of Merced formation.
		Purisima formation.	Tp		5400+	Conglomerate and sandstone at the base, thin-bedded shale in the middle, and soft light yellowish brown heavy-bedded sand toward the top.
		Santa Margarita formation.	Tsm		300±	Coarse white incoherent sand, conglomeratic at the base, overlain by thin-bedded hard shale.
		UNCONFORMITY				
	MIOCENE	Monterey shale.	Tm		5000±	Thinly laminated shale, largely diatomaceous, containing intercalated sandstone and calcareous concretionary layers. Locally bituminous and lignitic. Conformable with the Vaqueros on the west side of Ben Lomond Mountain.
		UNCONFORMITY				
		Vaqueros sandstone.	Tv		2700±	Coarse brown sandstone, conglomeratic toward the base, interbedded with dark earthy shale in certain areas. Fine sandstone of transitional Oligocene–Miocene age locally at the base.
		UNCONFORMITY				
	OLIGOCENE	San Lorenzo formation.	Tsl		2500±	Fine clay shale with interbedded brown sandstone toward top and bottom.
		Butano sandstone.	Tb		2100±	Massive brown and buff sandstones with conglomerate at the base.
		SEQUENCE CONCEALED				
	EOCENE	Limestone in diabase.	(Tl)		200±	Impure fossiliferous limestone inclusions in diabase dikes on the west flank of the Cahil–Castle Rock divide.
		SEQUENCE CONCEALED				
CRETACEOUS	UPPER CRETACEOUS	Chico formation.	Kc		10,000±	Thick-bedded coarse conglomerate, massive to thin-bedded sandstone, and sandy shale.
					(750)	Hard, flinty, even-bedded shale.
	LOWER CRET.	UNCONFORMITY				
		Knoxville formation.	Kk		100±	Conglomerate and sandstone; also dark thin-bedded clay shale, mapped with the Franciscan formation in Monte Bello Ridge.
JURASSIC?		UNCONFORMITY				
		Franciscan formation.	fc		1000±	Chiefly an earthy sandstone in which are minor quantities of dark shale similar to the Knoxville. Contains jasper lentils and some schist.
PRE-JURASSIC?		UNCONFORMITY				
		Schist and limestone.	ls sch		1000±	Quartz-mica schist and crystalline limestone, Intruded by quartz diorite which is cut by dikes of pegmatite and by quartz veins that are locally mineralized.
		Intrusive quartz diorite.	qd			

ILLUSTRATIONS I

FIG. 4.—CONGLOMERATE OF CHICO FORMATION ON THE COAST 2½ MILES NORTH OF PIGEON POINT, SAN MATEO COUNTY, LOOKING NORTHWEST.

FIG. 5.—UNCONFORMITY BETWEEN THE UPTURNED CHICO FORMATION ON THE RIGHT AND THE BUTANO SANDSTONE (OLIGOCENE) ON THE LEFT.

On the coast one-half mile south of the mouth of Pescadero Creek, San Mateo County.

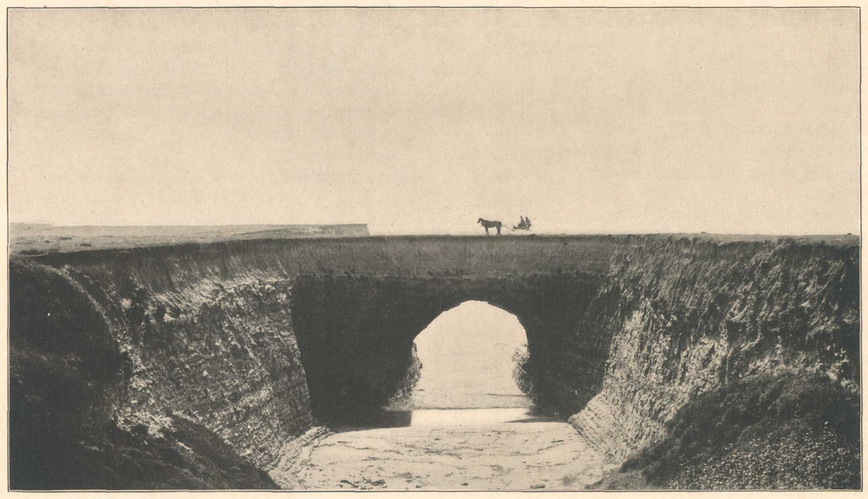


FIG. 6.—NATURAL BRIDGE IN MONTEREY SHALE, WHICH IS OVERLAIN BY 15 FEET OF QUATERNARY DEPOSITS FORMING THE SURFACE OF THE LOWEST MARINE TERRACE.

On the coast, 3 miles west of Santa Cruz.

FIG. 7.—VIEW LOOKING EAST FROM THE TOP OF THE 40-FOOT MARINE TERRACE 1 MILE EAST OF POINT AÑO NUEVO, SAN MATEO COUNTY.

Vertical bluff on the left shows truncated beds of Purisima formation overlain by Quaternary deposits, the top of which forms the surface of the terrace. Merced formation in the white bluffs on the right; white Miocene shales form the hills in the distance.

FIG. 8.—WAVE EROSION IN THE MIOCENE SHALE WEST OF SANTA CRUZ.

Erosion by the waves is fastest along joint lines in the shale, as shown by the parallel channels in the foreground. Quaternary sand and clay rest on the shale in the right middle distance, forming the surface of the lowest marine terrace.

FIG. 9.—EAST END OF SANDSTONE DIKE WEST OF THE MOUTH OF BALDWIN CREEK, SHOWING SEVERAL BRANCHES OF THE DIKE.

Exposed only at low tide.

FIG. 10.—SANDSTONE DIKE WEST OF THE MOUTH OF LAGUNA CREEK.

The dike is a soft sandstone, almost free from bitumen, and is therefore much less resistant to wave action than the shales, as is shown by the narrow trench in the foreground.

FIG. 11.—BITUMINOUS SANDSTONE BED OVERLAIN BY WHITE MONTEREY (MIOCENE) SHALE, QUARRY OF THE CITY STREET IMPROVEMENT COMPANY.

Six miles northwest of Santa Cruz.

FOSSILS COMMONLY FOUND IN OR CHARACTERISTIC OF THE FORMATIONS IN THE SANTA CRUZ QUADRANGLE.

SHOWN ON ILLUSTRATION SHEET II.

(Unless otherwise stated, all figures are natural size. L. S. J. U. refers to Leland Stanford Junior University collection; U. S. N. M., to United States National Museum.)

KNOXVILLE FORMATION (LOWER CRETACEOUS).

1. *Aucella crassicollis* Keyserling. L. S. J. U., No. 1014. Right valve; altitude 35 mm. Shape of shell variable. From the fine conglomerate west of Redwood and in the black shale on Stevens Creek.
2. *Amberlya dilleri* Stanton. L. S. J. U., No. 1011. Back view; altitude 16 mm. Twice natural size. Rare at same horizon as No. 1.

CHICO FORMATION (UPPER CRETACEOUS).

3. *Mactra stantoni* Arnold. U. S. N. M., No. 31001. Type; left valve; altitude 33 mm. Common in sandstones north of Pigeon Point.
4. *Glycymeris veatchii* Gabb. L. S. J. U., No. 1004. Umbones and hinge area; latitude 66 mm. At same locality as preceding.
5. *Trigonia evansiana* Meek. U. S. N. M., No. 31002. Umbones and hinge area; length of specimen 109 mm. Found in sandstones southeast of Pigeon Point. A somewhat similar form, *T. leana* Gabb, having nodose ribs, occurs with this species.
6. *Arca vancouverensis* Meek. U. S. N. M., No. 31003. Left valve; longitude 31 mm. Enlarged 1½ times. Common in sandstone southeast of Pigeon Point.
7. *Turritella pescaderoensis* Arnold. L. S. J. U., No. 999. Type; back view; altitude 46 mm. From conglomerate north of Bolsa Point.

EOCENE.

8. *Pecten* (*Chlamys*) *proavus* Arnold. U. S. N. M., No, 164930. Type; decorticated left valve; altitude 38 mm. Occurs in impure limestones at head of Pescadero Creek.
9, 9a. *Hipponyx carpenteri* Arnold. U. S. N. M., No. 165433. Type; top and side views of nearly perfect specimen. Enlarged three times. Found with the preceding.
10. *Patella mateoensis* Arnold. U. S. N. M., No. 165437. Type; top view; longitude 7 mm. Enlarged three times. Found with the preceding.
11. *Fissurella perrini* Arnold. U. S. N. M., No. 165434. Type; top view of slightly imperfect specimen; longitude 16 mm. Twice natural size. Not a common species.
12. *Tritonium newsomi* Arnold. U. S. N. M., No. 165436. Type; back view; altitude 16 mm. Twice natural size. Found with the preceding.
13. *Cidaris merriami* Arnold. U. S. N. M., No. 165438. Type; fragment of spine; longitude 21 mm. Twice natural size. Abundant with the preceding.
14, 14a. *Terebratulina tejonensis* Stanton. U. S. N. M., No. 165432; L. S. J. U., No. 1023. Ventral valve and dorsal valve; altitudes 15 and 11 mm. Twice natural size. Common with the preceding.
15. *Semele gayi* Arnold. U. S. N. M., No. 165435. Type; right valve; latitude 14 mm. Twice natural size. Occurs with the preceding.

SAN LORENZO FORMATION (OLIGOCENE).

16. *Tellina lorenzoensis* Arnold. U. S. N. M., No. 165439. Plastotype; left valve; longitude 40 mm. Abundant in the San Lorenzo, especially on the headwaters of Waddell Creek.
17. *Cardium cooperi* Gabb var. *lorenzanum* Arnold. L. S. J. U., No. 1077. Right valve; altitude 8 mm. Enlarged three times. Found commonly in the San Lorenzo shales and fine sandstones; also in Oligocene of Washington.
18. *Pecten* (*Pecten*) *sanctæcruzensis* Arnold. L. S. J. U., No. 1102. Plastotype; left valve; altitude 52 mm. Not uncommon in the Oligocene and transition Oligocene-Miocene beds.
19. *Fusus sanctæcrucis* Arnold. L. S. J. U., No. 1037. Plastotype; aperture of imperfect and decorticated specimen; altitude 43 mm. Found in the upper part of the formation.
20. *Haminea petrosa* Conrad. U. S. N. M., No. 165454. back view of slightly imperfect specimen; longitude 7 mm. Enlarged three times. Found at most fossiliferous localities of the San Lorenzo.
21. *Pleurotoma sanctæcrucis* Arnold. U. S. N. M., No. 165445. Plastotype; cast of imperfect mold; altitude 8.5 mm. Twice natural size. A characteristic species of this formation.
22. *Dentalium substriatum* Conrad. U. S. N. M., No. 165453. Lateral view of fragment; altitude 12 mm. Twice natural size. Common in the shales.
23. *Strepsidura californica* Arnold. U. S. N. M., No. 165450. Type; back view; altitude 33 mm. Not common in the shales and fine sandstones. Sometimes grows to twice the size of this specimen. Found also in Oligocene at Porter, Wash.
24. *Turcicula sanctacruzana* Arnold. U. S. N. M., No. 165442. Type: front of nearly perfect specimen; altitude 36 mm. A most beautiful and characteristic species; from the shales on San Lorenzo River.
25. *Pleurotoma newsomi* Arnold. U. S. N. M., No. 165440. Plastotype; back view; altitude 19 mm. Twice natural size. From the fine, soft sandstones.
26. *Fusus hecoxi* Arnold. U. S. N. M., No. 165446. Type; back view of imperfect specimen; altitude 35 mm. Found in the fine gray shale at the type locality of the formation on San Lorenzo River.
27. *Cidaris branneri* Arnold. L. S. J. U., No. 1056. Plastotype; lateral view of nearly perfect specimen; longitude 20 mm. Twice natural size. Occurs in upper part of formation.
28. *Architectonica lorenzoensis* Arnold. U. S. N. M., No. 165448. Plastotype; top view of nearly perfect specimen; maximum diameter 11 mm. Twice natural size. From the soft, fine sandstones.
29. *Nucula* (*Acila*) *dalli* Arnold. U. S. N. M., No. 165452. Plastotype; left valve; longitude 35 mm. This species is common in the shales of the San Lorenzo and has also been found in the supposed Monterey between the mouths of Waddell and Año Nuevo creeks.
30. *Aturia ziczac* Sowerby. L. S. J. U., No. 1089. The figure shows the only authentic fragment of this species so far found in the quadrangle. This form is closely allied to *Nautilus*, the figure showing the chambered aspect, with suture lines plainly exposed. Supposed to be characteristic of the Oligocene; found here in beds supposed to be upper San Lorenzo. Altitude of fragment 27 mm.
31. *Lirofusus ashleyi* Arnold. U. S. N. M., No. 165449. Type; back view of nearly perfect specimen; altitude 12.5 mm. Twice natural size. From the fine gray shale on San Lorenzo River.
32. *Malletia chehalisensis* Arnold. L. S. J. U., No. 1062. Right valve; slightly imperfect; longitude (restored), 12.5 mm. Found at several localities in this formation; also in the Oligocene of Oregon and Washington.
33. *Pleurotoma perissolaxoides* Arnold. U. S. N. M., No. 165451. Plastotype; back view of nearly perfect cast; altitude 12.5 mm. Twice natural size. From the fine sandstones.

VAQUEROS FORMATION (LOWER MIOCENE).

34. *Cardium* (*Trachycardium*) *vaquerosensis* Arnold. U. S. N. M., No. 165457. Type; imperfect right valve; longitude 65 mm. A characteristic species of the lower Miocene. Grows to more than 150 mm. (6 inches) in length.
35. *Glycymeris branneri* Arnold. U. S. N. M., No. 165455. Type; left valve; altitude 64 mm. Abundant in the lower Miocene, especially in Mindego Canyon.
36. *Leda cahillensis* Arnold. L. S. J. U., No. 1065. Type; left valve; longitude 7 mm. Enlarged three times. In Miocene sandstones west of Woodside.
37. *Pecten* (*Lyropecten*) *magnolia* Conrad. Collection, Univ. California. Right valve; altitude 145 mm. Characteristic of the Vaqueros formation; abundant at most fossiliferous localities.
38. *Turritella ineziana* Conrad (*Turritella hoffmanni* Gabb of most authors). U. S. N. M., No. 165459. Back view of imperfect but characteristic specimen; altitude 73 mm. Common in and characteristic of the lower Miocene (Vaqueros).
39. *Chione temblorensis* Anderson. U. S. N. M., No. 165474. Left valve; altitude 122 mm. Reduced one-half. Common in the Vaqueros; usually associated with the two preceding.
40. *Agasoma kernianum* Cooper. U. S. N. M., No. 165456. Back view of a specimen from Kern County; altitude 45 mm. A common species in the lower Miocene, or "*Agasoma* horizon," of the quadrangle.
41. *Terebratalia* (*aff.*) *occidentalis* Dall. L. S. J. U., No. 1091. Internal cast of dorsal valve; longitude 31 mm. Common in the Miocene of Tuff Hill, southeast of Stanford University.
42. *Yoldia submontereyensis* Arnold. U. S. N. M., No. 165459. Plastotype; right valve; longitude 32 mm. Common throughout the lower Miocene (Vaqueros).
43. *Turritella ocoyana* Conrad. U. S. N. M., No. 165474. Cast of a fragment of one of these long-spired shells; altitude 31 mm. Common in and characteristic of certain portions of the lower Miocene.
44. *Agasoma santacruzana* Arnold. L. S. J. U., No. 1072. Type; back view of young specimen; altitude 26 mm. Twice natural size. Another very common species in the "*Agasoma* horizon" (lower Miocene) of this quadrangle; found also at Coalinga, Fresno County.
45. *Pecten* (*Chlamys*) *branneri* Arnold. L. S. J. U., No. 1092. Plastotype; cast of fragment of a left valve; hinge line 33 mm. A common species in the Miocene of Tuff Hill; found also in the transition Oligocene-Miocene in Two Bar Creek.
46. *Tivela ineziana* Conrad. U. S. N. M., No. 165458. Slightly broken right valve; longitude 61 mm. A characteristic and common Vaqueros species.

MONTEREY FORMATION (MIDDLE MIOCENE).

47. *Mactra montereyana* Arnold. U. S. N. M., No. 165463. Type; longitude of each valve 31 mm. A not uncommon form in the Monterey; usually distorted.
48. *Venericardia montereyana* Arnold. U. S. N. M., No. 165464. Type; left valve; longitude 10 mm. Twice natural size. Not uncommon in the Monterey shale; usually distorted.
49. *Yoldia impressa* Conrad. U. S. N. M., No. 165465. Cast of distorted (longitudinally elongated) right valve, showing teeth of left valve above; longitude 26 mm. Nearly all the fossils in the Monterey shale are distorted. The normal form of this common species is much broader, and pointed at the end broken in this specimen.
50. *Arca obispoana* Conrad. U. S. N. M., No. 165462. Cast of right and left valves; longitude of more nearly perfect specimen, 42 mm. Common in the Monterey shale about Felton and Newell Creek, and also in the Salinas and adjacent valleys.
51. *Pecten* (*Propeamusium*) *stanfordensis* Arnold. Collection, Delos Arnold. Type; cast of right valve and mold of left, altitude 7 mm. Enlarged three times. Common in shale of supposed Monterey age on the Burke ranch, southwest of Stanford University.
52. *Pecten* (*Pseudamusium*) *peckhami* Gabb. U. S. N. M., No. 164839. Casts of right and left valve in matrix. Common in the Monterey of the Coast Range; also occasionally found in the San Lorenzo formation, and even as low as the Eocene.

BARNACLE BEDS, LOWEST PURISIMA (?) (UPPER MIOCENE).

53. *Periploma sanctæcrucis* Arnold. L. S. J. U., No. 1074. Type; partly decorticated right valve; longitude 43 mm. Not an uncommon species at this horizon.
54. *Agasoma stanfordensis* Arnold. L. S. J. U., No. 1087. Type; back view of cast of imperfect specimen; altitude 52 mm. Supposed to be characteristic of this horizon.
55. *Fusus stanfordensis* Arnold. L. S. J. U., No. 1081. Back view of sandstone cast of nearly perfect specimen; altitude 49 mm. Supposed to be characteristic of this horizon.
56. *Yoldia supramontereyensis* Arnold. L. S. J. U., No. 1067. Type; imperfect left valve; longitude 40 mm. This species is characterized by its long curved "beak."
57. *Leda taphria* Dall. L. S. J. U., No. 1069. Cast of right valve; longitude 18 mm. Twice natural size. Not uncommon at this horizon; also occurs recent.

SANTA MARGARITA FORMATION (UPPER MIOCENE).

58. *Astrodapsis antiselli* Conrad. U. S. N. M., No. 165466. Top view; longitude 54 mm. Supposed to be characteristic of the Santa Margarita horizon; found abundantly in the white Santa Margarita sandstone of the Scott Valley region. Figured specimen from Salinas Valley.
59. *Amphiura sanctæcrucis* Arnold. U. S. N. M., No. 165431. Paratype; nearly perfect mold of ventral side of one of these beautiful animals. Among the few fossils found in the shale overlying the white sand of Scott Valley.

PURISIMA AND MERCED FORMATIONS (UPPER MIOCENE AND PLIOCENE).

60. *Pecten* (*Patinopecten*) *purisimaensis* Arnold. Collection, Delos Arnold. Type; right valve; altitude 123 mm. Reduced one-half. The left valve has much narrower, lower ribs and broad interspaces. Common in the Purisima formation below the *Pecten healeyi* horizon.
61. *Cardium meekianum* Gabb. L. S. J. U., No. 1098. Decorticated left valve; altitude 73 mm. A common form in the Purisima and other upper Miocene and Pliocene formations.
62. *Arca schizotoma* Dall. L. S. J. U., No. 1090. A nearly perfect right valve; longitude 56 mm. A very common species in the Pliocene. Closely allied to *A. trilineata* Conrad and *A. canalis* Conrad.
63. *Chlorostoma stantoni* Dall var. *lahondaensis* Arnold. L. S. J. U., No. 1079. Back view of type; a slightly imperfect specimen; altitude 21 mm. Appears to be characteristic of the middle fauna of the Purisima.
64. *Miopleiona oregonensis* Dall. U. S. N. M., No. 165469. Aperture view of a nearly perfect specimen; altitude 78 mm. This species appears to be characteristic of the middle and upper Purisima in this quadrangle.
65. *Chrysodomus stantoni* Arnold. L. S. J. U., No. 1088, Paratype; the canal and upper whorls are broken off in this specimen; altitude 79 mm. A common form all through the Pliocene.
66. *Schizothærus pajaroanus* Conrad. U. S. N. M., No. 165467. Left valve; longitude 72 mm. A common species in the Pliocene.
67. *Pecten* (*Patinopecten*) *healeyi* Arnold. Collection, Delos Arnold. Imperfect right valve; hinge line 50 mm. Reduced one-half. Very common at one horizon in the Purisima near San Gregorio and Pescadero.
68. *Fusus portolaensis* Arnold. L. S. J. U., No. 1080. Paratype; aperture view of imperfect specimen; altitude 58 mm. Common in the Purisima on the east side of the range.
69. *Cryptomya ovalis* Conrad. L. S. J. U., No. 1097. Left valve; longitude 28.5 mm. A common form all through the Purisima.
70. *Phacoides annullatus* Reeve. U. S. N. M., No. 165470. Right valve; longitude 50 mm. A common species in the Purisima and Merced; also occurs recent.
71. *Nucula* (*Acila*) *castrensis* Hinds. U. S. N. M., No. 165471. Left valve; longitude 15 mm. Twice natural size. A common species in the Pliocene; found also in the Quaternary.
72. *Tapes staleyi* Gabb. L. S. J. U., No. 1094. Right valve; longitude 46 mm. A common species in the Pliocene.

SPECIES FOUND MORE COMMONLY IN THE MERCED FORMATION (UPPER PLIOCENE).

73. *Nassa californiana* Conrad. L. S. J. U., No. 1095. Aperture view; altitude 31 mm. A common species in the Pliocene.
74. *Thais trancosana* Arnold. L. S. J. U., No. 1082. Type; aperture view of imperfect specimen; altitude 23 mm. Found in the Merced.
75. *Thais ostrina* Gould. L. S. J. U., No. 1096. Aperture view of imperfect specimen; altitude 23 mm. Found in the Merced; also recent.
76. *Bittium asperum* Gabb. U. S. N. M., No. 165472. Aperture view of slightly imperfect specimen; altitude 26 mm. Enlarged three times. Common in the Pliocene.
77. *Astyris richthofeni* Gabb. U. S. N. M., No. 165468. Aperture view; altitude 8 mm. Enlarged three times. Common in the Pliocene.
78. *Littorina petricola* Dall. L. S. J. U., No. 1099. Aperture view of imperfect specimen; altitude 10 mm. Found in the Merced.

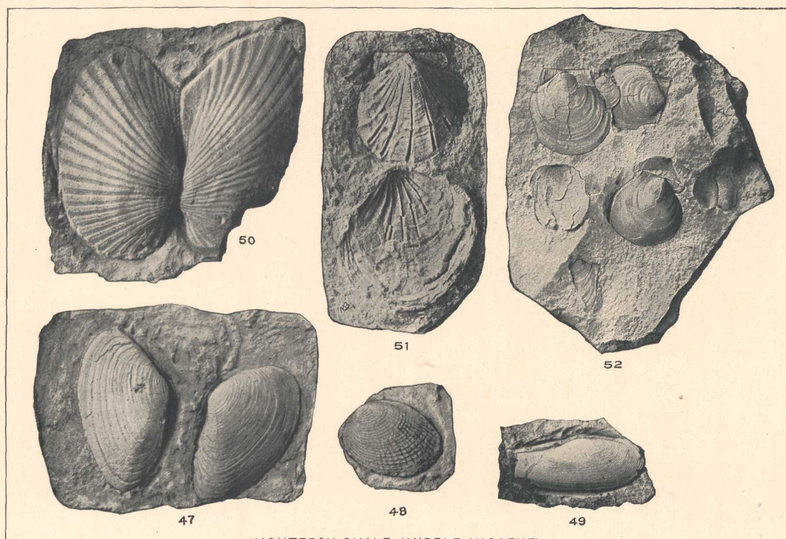
SANTA CLARA FORMATION (FRESH-WATER PLIOCENE AND QUATERNARY).

79. *Anodonta wahlametensis* Lea. L. S. J. U., No. 1100. Slightly imperfect right valve; longitude 75 mm. From the Santa Clara formation, associated with several kinds of small snails, such as *Amnicola*, etc.

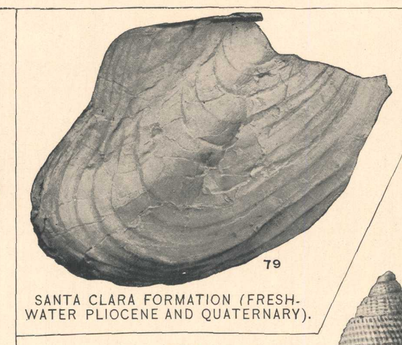
U. S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

ILLUSTRATIONS II

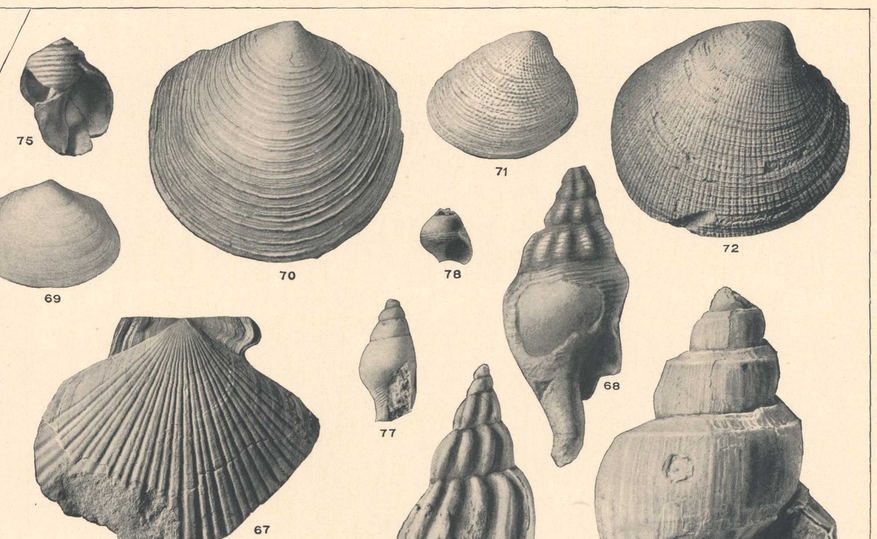
CALIFORNIA
SANTA CRUZ QUADRANGLE

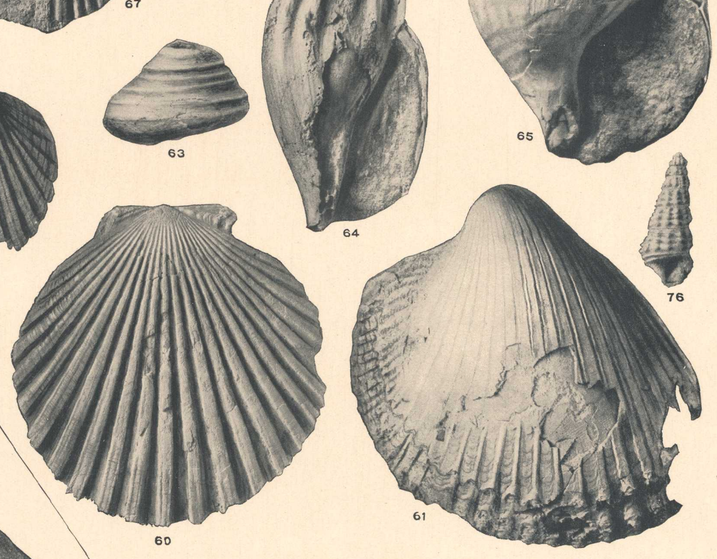


MONTEREY SHALE (MIDDLE MIOCENE).



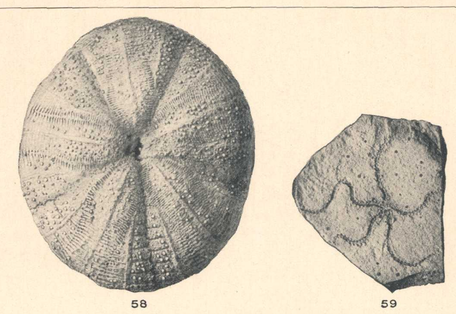
SANTA CLARA FORMATION (FRESH-WATER PLIOCENE AND QUATERNARY).





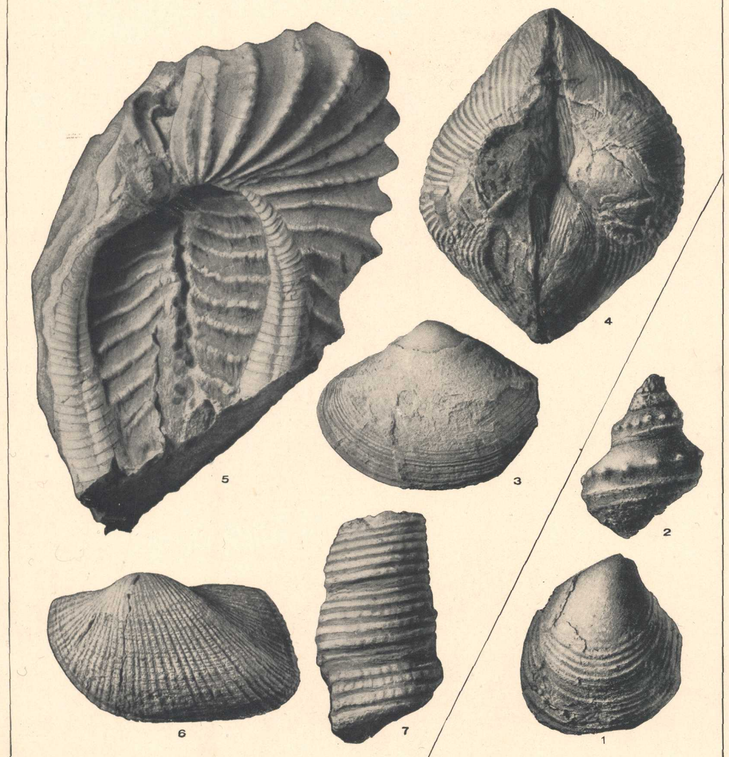
PURISIMA AND MERCED FORMATIONS (PLIOCENE).

VAQUEROS SANDSTONE (LOWER MIOCENE).

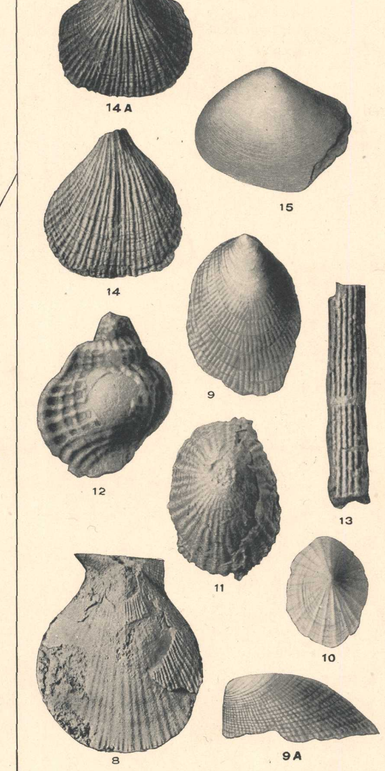


SANTA MARGARITA FORMATION (UPPER MIOCENE).

BARNACLE BEDS, LOWEST PURISIMA(?) (UPPER MIOCENE).

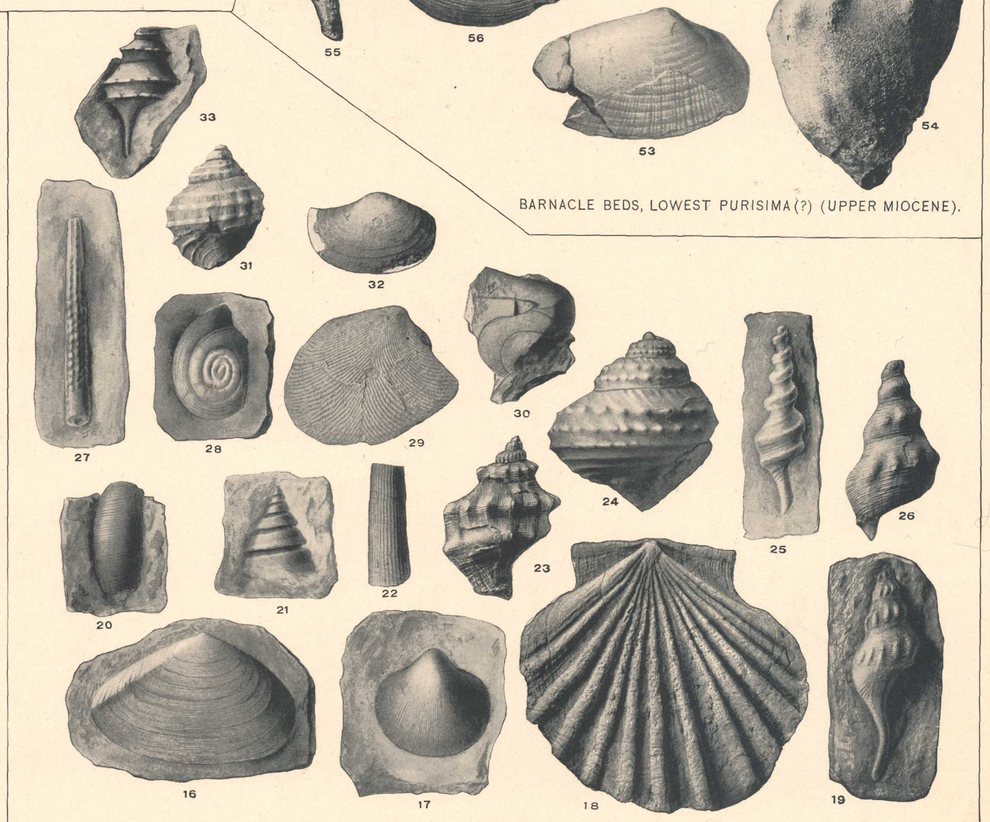


CHICO FORMATION
(UPPER CRETACEOUS).



KNOXVILLE FORMATION
(LOWER CRETACEOUS).

LIMESTONE OF EOCENE AGE.



SAN LORENZO FORMATION (OLIGOCENE).